CHAPTER 5

HOSE FABRICATION AND MAINTENANCE

Chapter Objective: *Upon completion of this chapter, you will have a working knowledge of the fabrication and maintenance of aircraft hydraulic and pneumatic hoses and their associated hardware.*

You are responsible for maintaining a portion of the hundreds of feet of fluid and air lines and various hardware and seals found in modern-day aircraft. The maintenance of these lines frequently involves fabrication and replacement of hose and hose assemblies. To be able to select the proper type of hose and hose assemblies and their hardware, you will need a basic knowledge of the type, size, and material from which items are to be made.

HOSE AND HOSE ASSEMBLIES

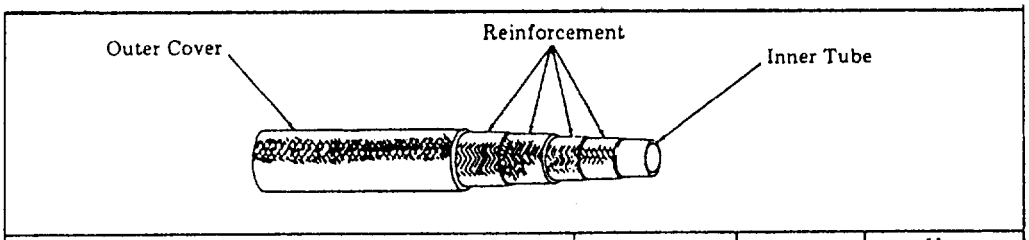
Learning Objective: *Identify the various types of hose, hose assemblies, hardware, tools, and equipment used on naval aircraft.*

Hose assemblies are used to connect moving parts with stationary parts and in locations subject to severe vibration. Hose assemblies are heavier than aluminum-alloy tubing and deteriorate more rapidly. They are used only when absolutely necessary. Hose assemblies are made up of hose and hose fittings. A hose consists of multiple layers of various materials. An example of the hose most often used in medium-pressure applications is shown in figure 5-1.

TYPES OF HOSE

There are two basic types of hose used in military aircraft and related equipment. They are synthetic rubber and polytetrafluoroethylene, commonly known as Teflon@ or PTFE.

Bulk hose identification will vary with the materials from which the hose is constructed. It is important that you are able to clearly identify the proper hose to be used by recognizing the various hose markings.



Construction Material			Intended Use	Cautions	Use To Fabricated Hose Assy
Inner Tube	Reinforcement	Outer Cover			
Synthetic rubber compound, seamless construction, resistant to: Petroleum base fuel, Lubricating oil and Hydraulic fluid	Inner cotton braid and wire braid	Synthetic rubber inpregnated, cotton braid, resistant to: Oil (petroleum base)	Medium pressure hydraulic, fuel, and petroleum base oil system applications		MIL-H-8795

Figure 5-1.—Medium pressure synthetic rubber hose, MIL-H-8794.

Synthetic Rubber Hose

Synthetic rubber hose has a seamless synthetic rubber inner tube covered with layers of cotton and wire braid, and an outer layer of rubber impregnated cotton braid. The hose is provided in low-, medium-, and high-pressure types.

Synthetic rubber hose (if rubber-covered) is identified by the indicator stripe and markings that are stencilled along the length of the hose. The indicator stripe (also called the lay line because of its use in determining the straightness or lie of a hose) is a series of dots or dashes. The markings (letters and numerals) contain the military specification, the hose size, the cure date, and the manufacturer's federal supply code number. This information is repeated at intervals of 9 inches. Refer to figure 5-2.

Size is indicated by a dash followed by a number (referred to as a dash number). The dash number does **not** denote the inside or outside diameter of the hose. It refers to the equivalent outside diameter of rigid tube size in sixteenths (1/16) of an inch. A dash 8 (-8) mates to a number 8 rigid tube, which has an outside diameter of one-half inch (8/16). The inside of the hose will not be one-half inch, but slightly smaller to allow for tube thickness.

The cure date is provided for age control. It is indicated by the quarter of the year and year. The year is divided into four quarters.

1st quarter — January, February, March

2d quarter — April, May, June

3d quarter — July, August, September

4th quarter — October, November, December

The cure date is also marked on bulk hose containers in accordance with Military Standard 129 (MIL-STD-129).

Synthetic rubber hose (if wire-braid covered) is identified by bands wrapped around the hose at the ends and at intervals along the length of the hose. Each band is marked with the same information (fig.5-2).

Teflon® Hose

The Teflon® hose is made up of a tetrafluoro-ethylene resin, which is processed and extruded into tube shape to a desired size. It is covered with stainless steel wire, which is braided over the tube for strength and protection. The advantages of this hose are its operating temperature range, its chemical inertness to all fluids normally used in hydraulic and engine lubrication systems, and its long life. At this time, only medium-pressure and high-pressure types are available. These are complete assemblies with factory-installed end fittings. The fittings may be either the detachable type or the swaged type. When failures occur, replacement must be made on a complete assembly basis.

Teflon® hose is identified by metal bands or pliable plastic bands at the ends and at 3-foot intervals. These bands contain the hose military specification number, size indicated by a dash (-) and a number, operating pressure, and the manufacturer's federal supply code number. Refer to figure 5-2.

HOSE ASSEMBLY HARDWARE

Hose fittings are designed and constructed in accordance with military specifications and military standard drawings for particular hose configurations and operating pressures.

Fittings designated by a military standard drawing number have a particular dash number to indicate size. The fitting dash number does not designate a size in the same manner as a hose dash number. The fitting dash number corresponds to the dash number of the hose so that both will match at the critical dimensions to form a hose assembly.

Materials used in the construction of fittings vary according to the application. Materials include aluminum, carbon steel, and corrosion-resistant steel. Fittings that qualify under one military document may be produced by several manufacturers. Two methods or styles are used to secure the hose fitting on to the hose. They are the reusable and swage or crimp style.

Reusable Style

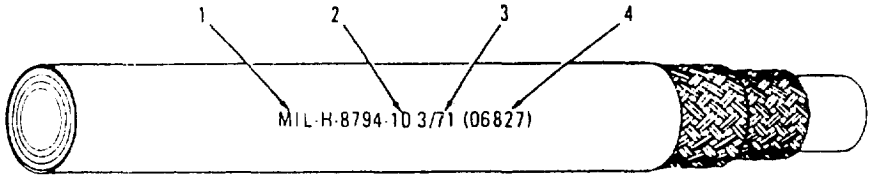
The preferred reusable style has modified internal threads in the socket to grip the hose properly. The fitting can be disassembled from a hose assembly and reused on another hose, provided it passes an inspection for defects. Reusable style fittings are authorized replacement fittings for replacement hose assemblies.

Swage or Crimp Style

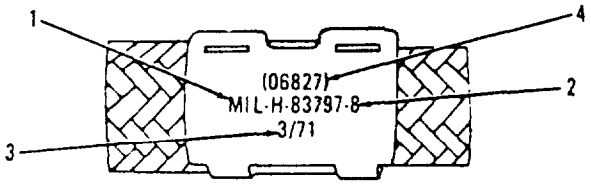
Some hose assembly manufacturers use a swage or crimp style. This style requires the socket to be permanently deformed by an electric- or hydraulic-powered machine. The deformed socket and related hardware are to be scrapped.

HOSE FITTINGS

Hose fittings are assemblies of separate parts. These parts are the nipple, the socket, the swivel nut or flange, and the sleeve. The nipple is the part that fits the inside diameter of the hose. Nipples have three configurations for the hose-to-tube or component surface-sealing portion. They are the flared,



SYNTHETIC RUBBER HOSE



WIRE BRAID COVERED SYNTHETIC RUBBER HOSE

1. MILITARY SPECIFICATION OF HOSE
2. SIZE INDICATED BY A DASH (–) NO. OR FRACTION OF AN INCH FOR MIL-H-6000 AND MIL-H-7938 HOSES
3. CURE DATE FOR AGE CONTROL
4. MANUFACTURER'S FEDERAL SUPPLY CODE NO.

MANUFACTURER	AEROQUIP
MANUFACTURER'S CODE	00624
PART NO. WITH DASH (SIZE) NO.	AE206-10
LOT NO.	305496
OPERATING PRESSURE	3000 PSI
MILITARY SPECIFICATION	MIL-H-83298

WIRE BRAID COVERED TEFLON HOSE LABEL

Figure 5-2.—Synthetic rubber hose identification

flareless, and flanged configurations, as shown in figure 5-3. The socket fits over the outside diameter of the hose and secures one end of the nipple to the hose. The swivel nut or flange secures the other end of the nipple to the mating connection in the fluid system. For Teflon@ hose, some manufacturers have a sleeve in addition to the nipple, socket, and nut or flange. See figure 5-4 for illustrations of Teflon@ hose fittings and sleeves. Individual parts produced by each manufacturer may have unique characteristics and tolerances that prevent interchangeability between parts. Do not intermix nipples and sockets from one manufacturer to another.

Hose fittings are identified by applicable military specification (MS) and manufacturer's name or trademark on fittings and nuts. Flared or flareless fittings and nuts are color-coded to show materials or material finishes. See table 5-1.

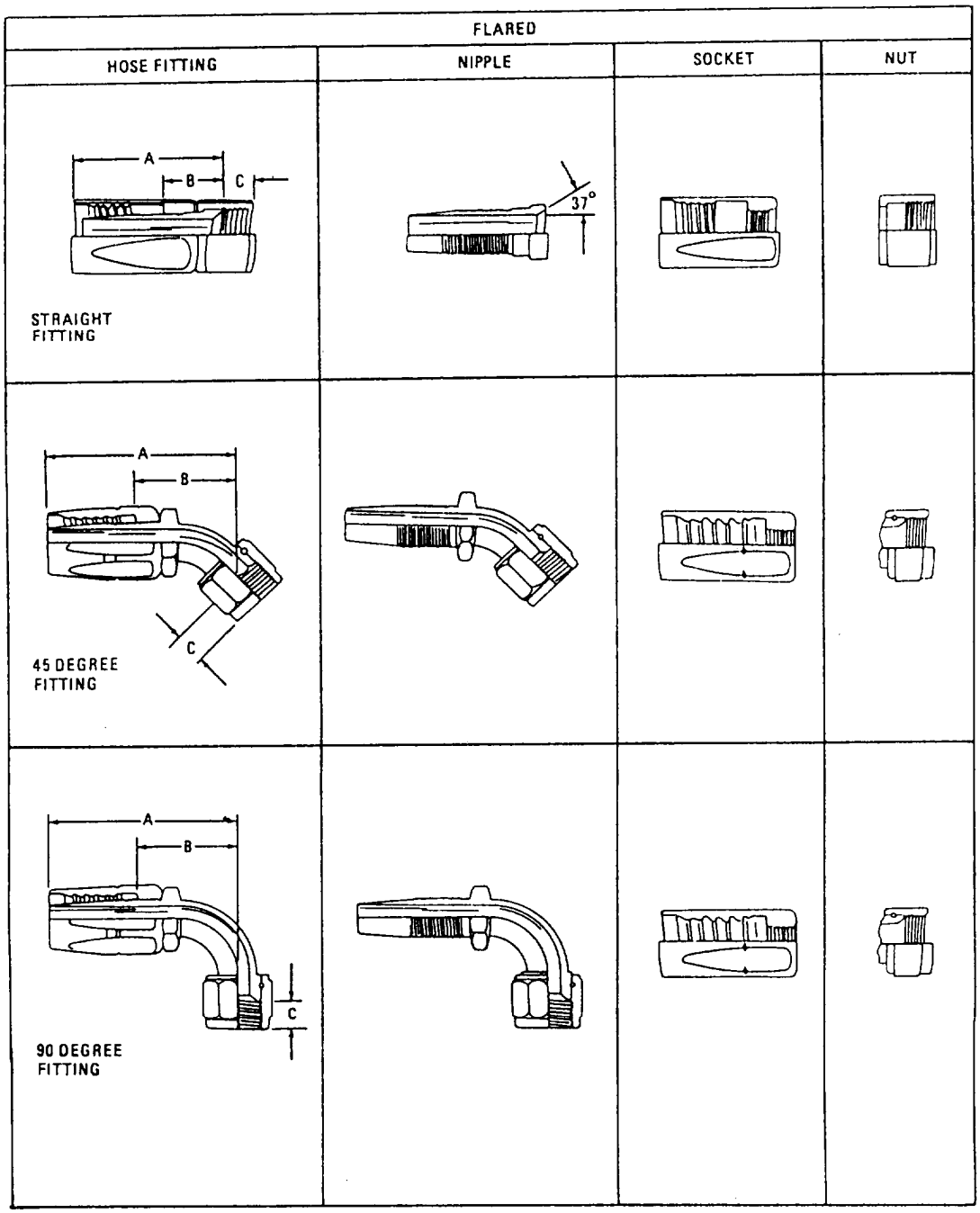


Figure 5-3.—Synthetic hose fittings.

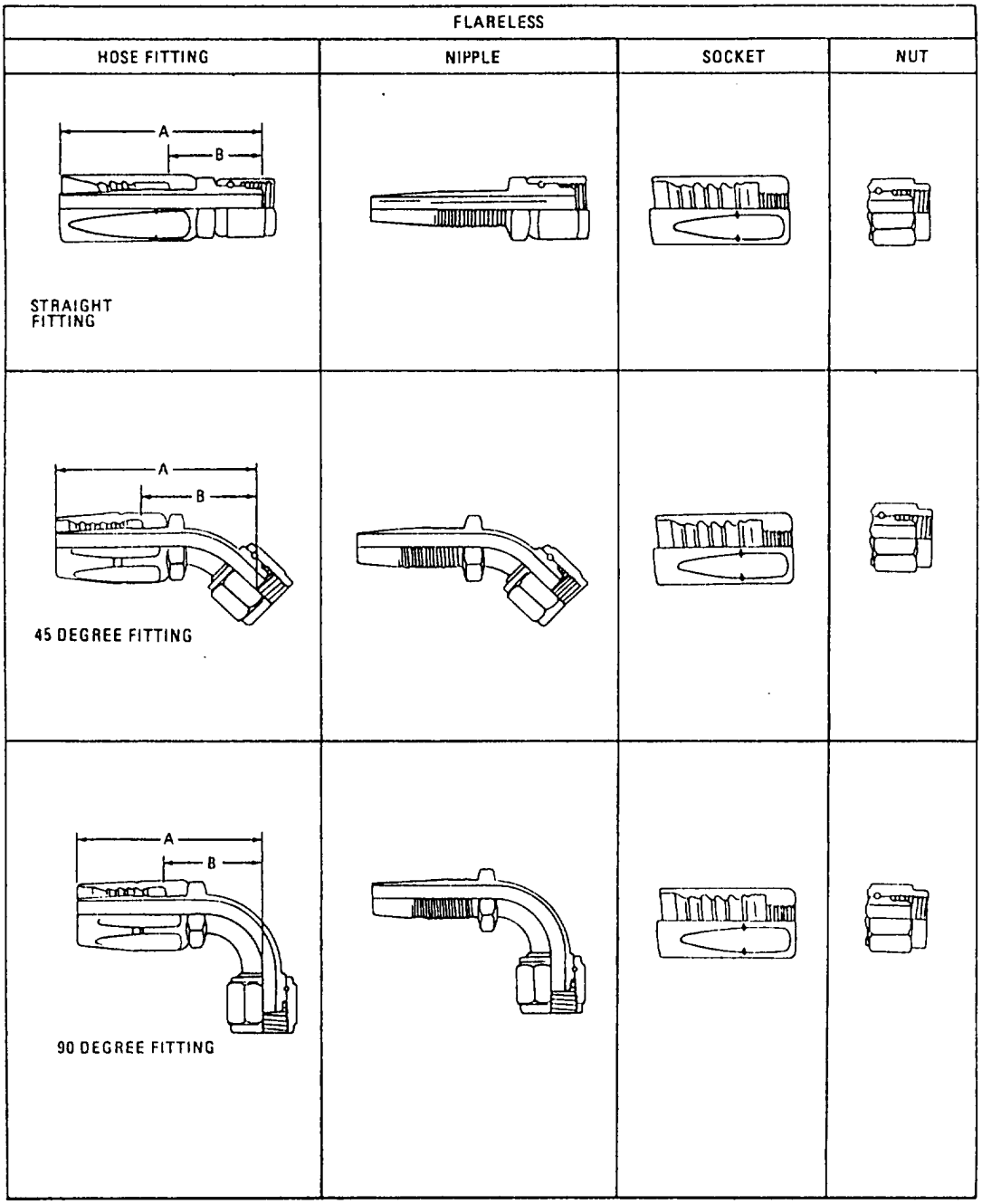


Figure 5-3.—Synthetic hose fittings—Continued.

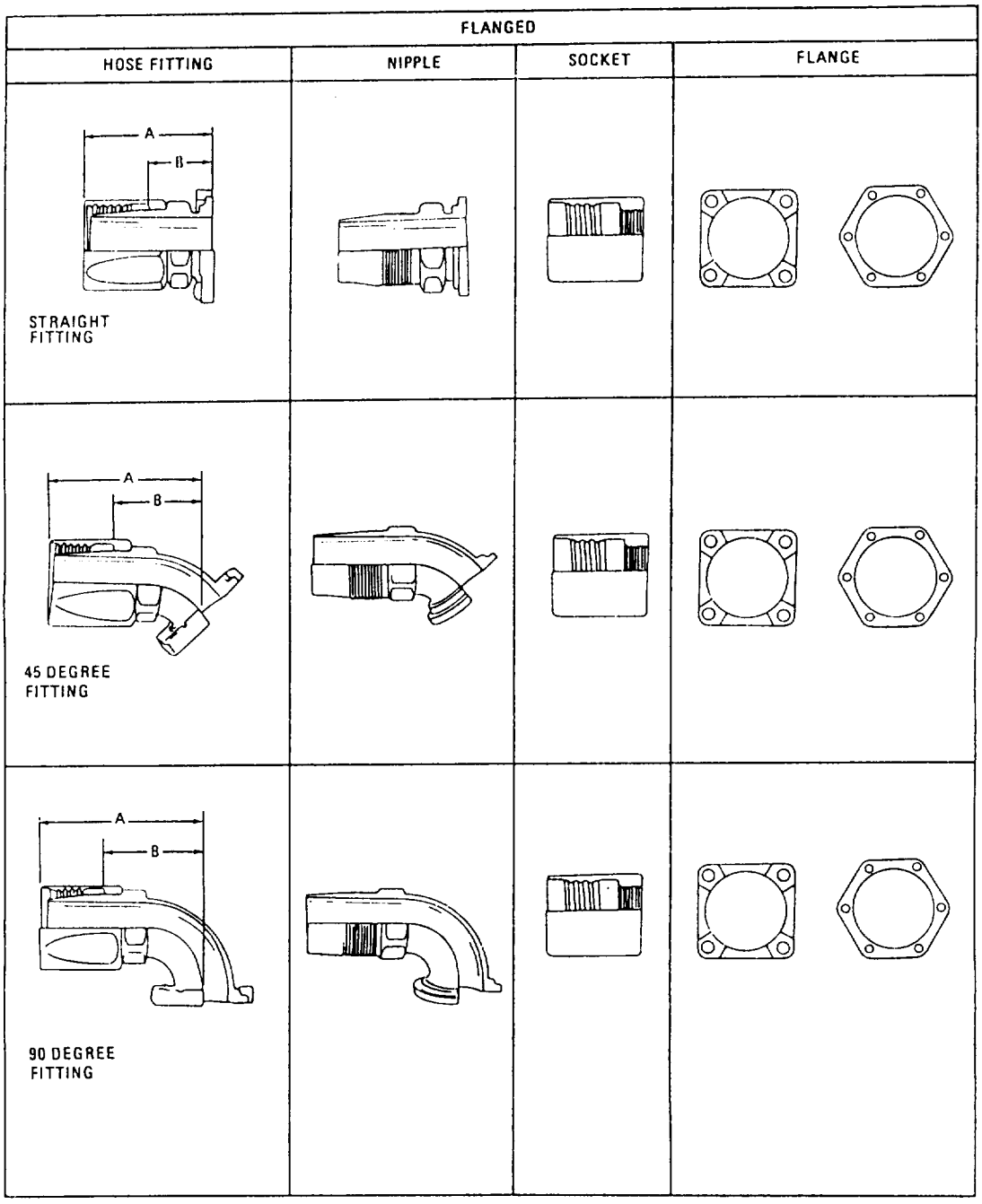


Figure 5-3.—Synthetic hose fittings—Continued.

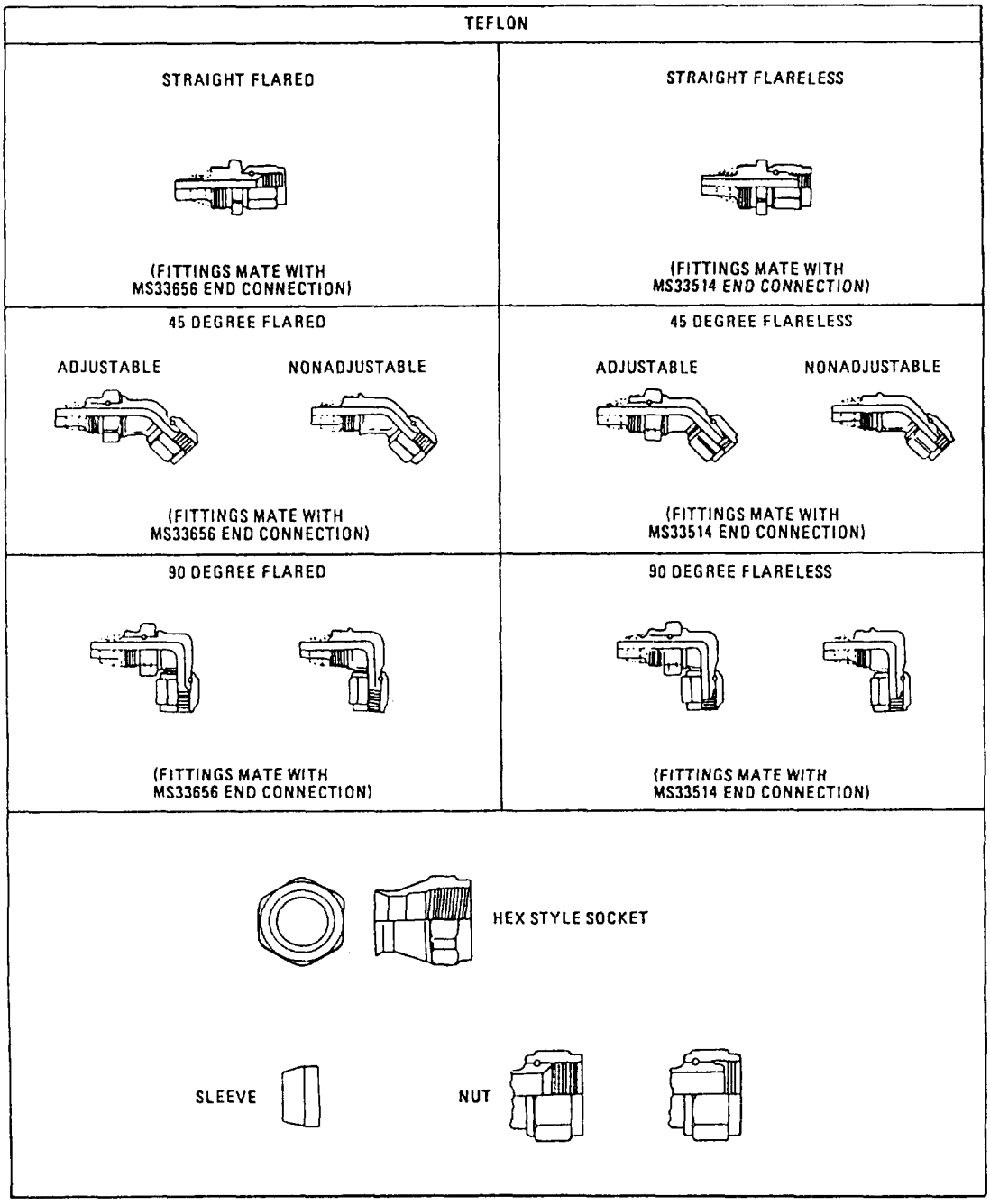


Figure 5-4.—Teflon® hose fittings.

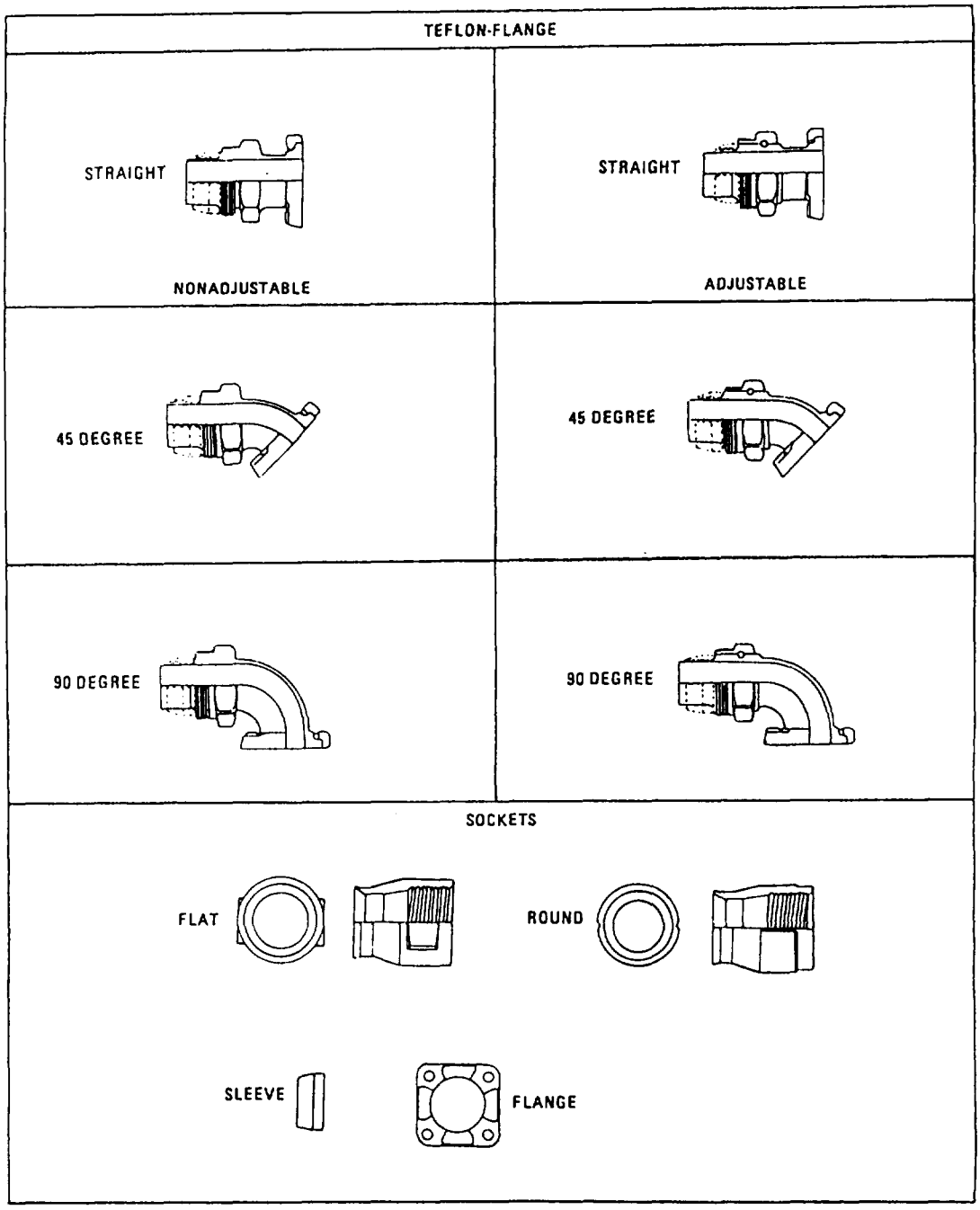


Figure 5-4.—Teflon® hose fittings—Continued.

Table 5-1.—Hose Fitting Color and Material Code

Flared Fittings MIL-F-5509	Color	Material Code
Aluminum Alloy 2014 and 2024(1)	Blue	D (Optional)
Aluminum 7075(1)	Brown	W(T-73)
Steel	Black	
Copper Based Alloys	Natural Cadmium Plate if Applicable	
Corrosion Resistant Steel	None	
Class 304		J
Class 316		K
Class 347		S
Titanium Alloys	Gray	T
Flareless Fittings MIL-F-18280	**Color**	**Material Code**
AluminumAlloy 2014 and 2024	Green	D
Aluminum Alloy 7075	Brown	W(T-73)
Carbon Steel	Yellow (result of Chromate treatment)	
4130 Steel Forging		F
Stainless Steel	Natural Finish	
Class 304		J
Class 316		K
Class 347		S
Titanium Alloy	Gray	T

NOTE

(1) Duplex steel may distort color of aluminum anodize.

All hose assemblies are identified by tags, bands, or tapes. Some identifications are permanently marked while others are removable. Removable tags, bands, or tapes should not be installed on hose assemblies located inside fuel and oil tanks or in areas of an aircraft where tags, bands, or tapes could be drawn into the engine intake. Hose assemblies are either commercially manufactured or locally fabricated.

COMMERCIALLY MANUFACTURED HOSE ASSEMBLIES

Commercially manufactured hose assemblies are made from synthetic rubber or Teflon®. The assemblies are identified by a band near one end of the assembly. This band identities the assembly manufacturer's code or trademark and military specification (MS) part number, including dash size, operating pressure (in pounds per square inch, psi), date of assembly (in quarter and year), hose manufacturer's code number (if different from assembly manufacturer), and the cure date of the hose manufacturer (in quarter and year).

The assembly date is indicated by the letter **A,** followed by the quarter of the year, the letter **Q,** and ends with the last two digits of the year. For example, hose assemblies fabricated during June 1980 are marked A2Q80. When a decal or band is used that states "assembly date," the A may be omitted. Assembly date information is also indicated on the unit, intermediate, and shipping containers containing a single item. Exterior shipping containers that contain major assemblies made up of two or more assemblies with rubber items are identified by the oldest assembly in the container.

Commercially manufactured Teflon® hose assemblies are identified by a permanently marked and attached band on the assembly. The band contains the assembly manufacturer's name or trademark; hose manufacturer's federal supply code number; hose assembly part number; operating pressure-in psi, pressure test symbol (PT), and the date of hose assembly manufacture (in month and year).

LOCALLY FABRICATED HOSE ASSEMBLIES

Hose assemblies manufactured by depot and intermediate maintenance activities are identified with hose assembly identification tags or labels. The hose assembly identification tag is a metal tag that contains the basic hose assembly and part number, date of fabrication (in quarter and year), operating pressure (in psi), and organizational code of the activity fabricating the hose assembly. Figure 5-5 shows where this information is located All marking of the tag is to be done prior to its attachment to the hose assembly. Install the hose assembly identification tag by wrapping the band snugly around the hose, inserting the tab through the slot and pulling it tight; crimp the tab after bending the tab back; and finally, cut away the excess tab after crimping. A length of not less than one-half inch must remain between the tag and the end fitting after proof pressure testing has been performed. Proof pressure testing is discussed later in this chapter.

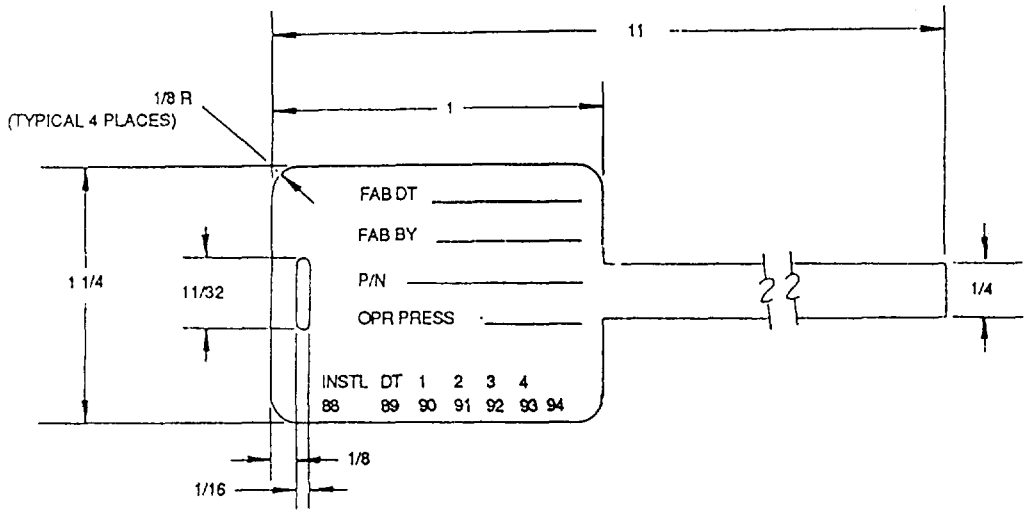
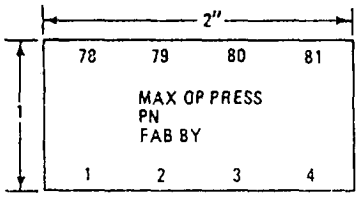


Figure 5-5.—Hose assembly identification tags.



(MATERIAL: WHITE POLYESTER FILM PER MIL-P-38477.)

Figure 5-6.—Hose assembly labels

Use labels (fig. 5-6) to identify hose assemblies located in areas where a tag may be drawn into an engine intake or where hose assemblies are covered with heat-shrinkable tubing. Place the label 1 inch from the socket and apply a 2 1/2-inch piece of clear, heat-shrinkable tubing, MIL-R-46846, type V, over the label and hose. Function and hazard labels can be applied in the same manner as described above.

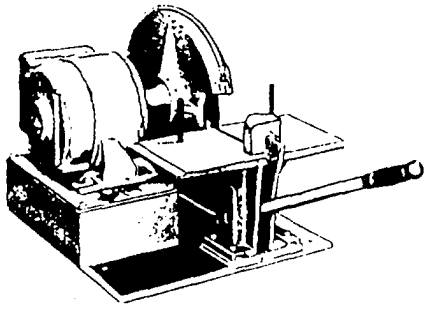
Fabrication

Fabricating hose assemblies from bulk hose and reusable end fittings requires some basic skills and a few hand tools. The skills required are the ability to follow step-by-step instructions and to use the required hand tools.

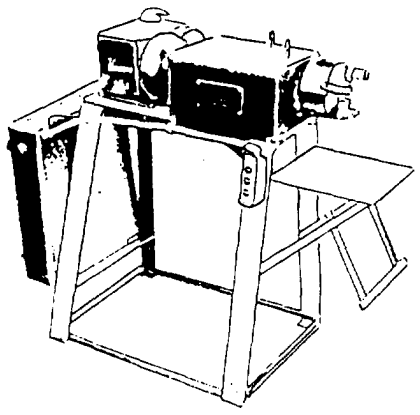
EQUIPMENT AND TOOLS.— Fabricating hose assemblies is a function of intermediate- and depot-level maintenance. The intermediate and depot shops are equipped with hose fabricating machines (fig. 5-7) and proof-test equipment. Each machine or equipment is supplied with operating instructions.

The basic hand tools that are required to fabricate hose assemblies up to 3,000 psi operating pressure are a bench vise, a hose cutoff machine, open end wrench sets, a sharp knife, slip joint pliers, an oil can for lubricating oil, a marking pencil, a small paint brush, masking or plastic electrical tape, a steel ruler, a thickness gauge (leaf type), and a protractor.

Mandrels are special hand tools (fig. 5-8) that are not required but are recommended for fabricating hose assemblies. During hose assembly fabrication, mandrels can be used to protect sealing surfaces, support inner tubes, and guide fitting nipples into hoses.

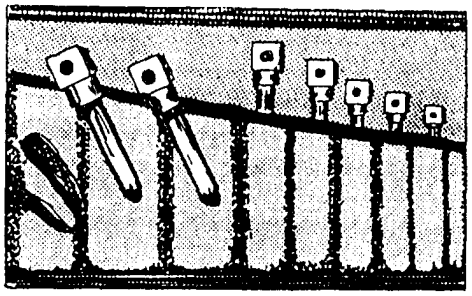


HOSE CUT OFF MACHINE



SOCKET ASSEMBLY MACHINE

Figure 5-7.—Hose fabricating machines.



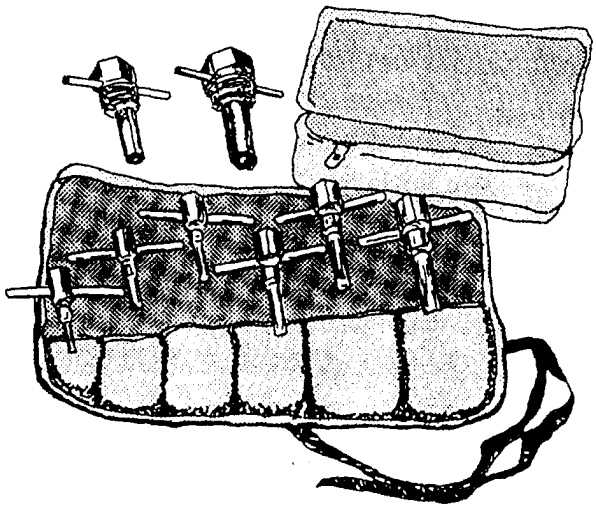


Figure 5-8.—Mandrel kits.

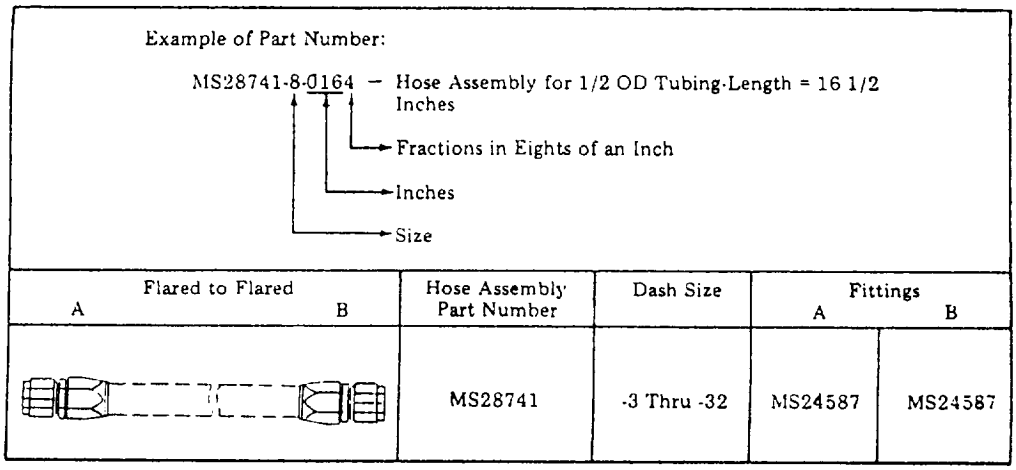


Figure 5-9.—Synthetic rubber medium-pressure hose assembly.

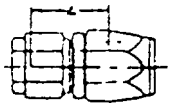
PROCEDURES.— When failure occurs in a flexible hose equipped with swaged end fittings, the unit is generally replaced without attempting a repair. The correct length of hose, complete with factory-installed end fittings, is drawn from supply.

When failures occur in hose assemblies equipped with reusable style end fittings, the fabrication of the replacement unit is the function of the intermediate and depot organization levels. Undamaged end fittings on the old length of hose maybe removed and reused; otherwise, new fittings must be drawn from supply along with a sufficient length of hose.

The following assembly procedures are for instructional purposes only. When fabricating hose assemblies, refer to the *Aviation Hose and Tube Manual,* NAVAIR 01-1A-20. Hose assembly part number MS 28741-80164 (fig. 5-9), per MIL-H-8795, is used here as an example of fabrication procedures.

The first step is to determine the necessary hose length from table 5-2 and figure 5-10. Wrap the circumference of the hose with masking or plastic electrical tape at the cutoff to prevent flare-out of braid if the hose outer cover is wire braid. Hose with rubber or fabric outer cover does not require wrapping

Table 5-2.—Hose Cutoff Factor (In Inches)

	FITTING	HOSE SIZE (DASH NUMBER AND/OR LETTER)										
	P/N	-3	-4	-5	-6	-8	-10	-12	-16	-20	-24	-32
STRAIGHT FLARED 	MS27616		.92		1.02	1.16						
	MS27053	.70	.74	.77	.81	.93	1.05	1.13	1.30	1.44	1.66	
	MS28760		.79		.99	1.10	1.19	1.35	1.59			
	MS18085	.42	.41	.42	.47	.58	.63	.61	.67	.79	.86	
	MS24587	.60	.60	.70	.77	.94	1.00	1.00	.94	.99	1.09	1.24
	MS27404		.46		.55	.68	.73					
	MS87018	.64	.65	.70	.76	.94	.99	1.00	1.16	1.34	1.44	1.62
	OR											
	M83798/1	{ .74*	.74*	.76*	.84*	97*	1.05*	1.11*	1.34*	1 .54*	1 .70*	

NOTES:

Δ Cut-off factor for one fitting.

* Hose fittings manufactured by Stratoflex (98441) have different cut-off factors,

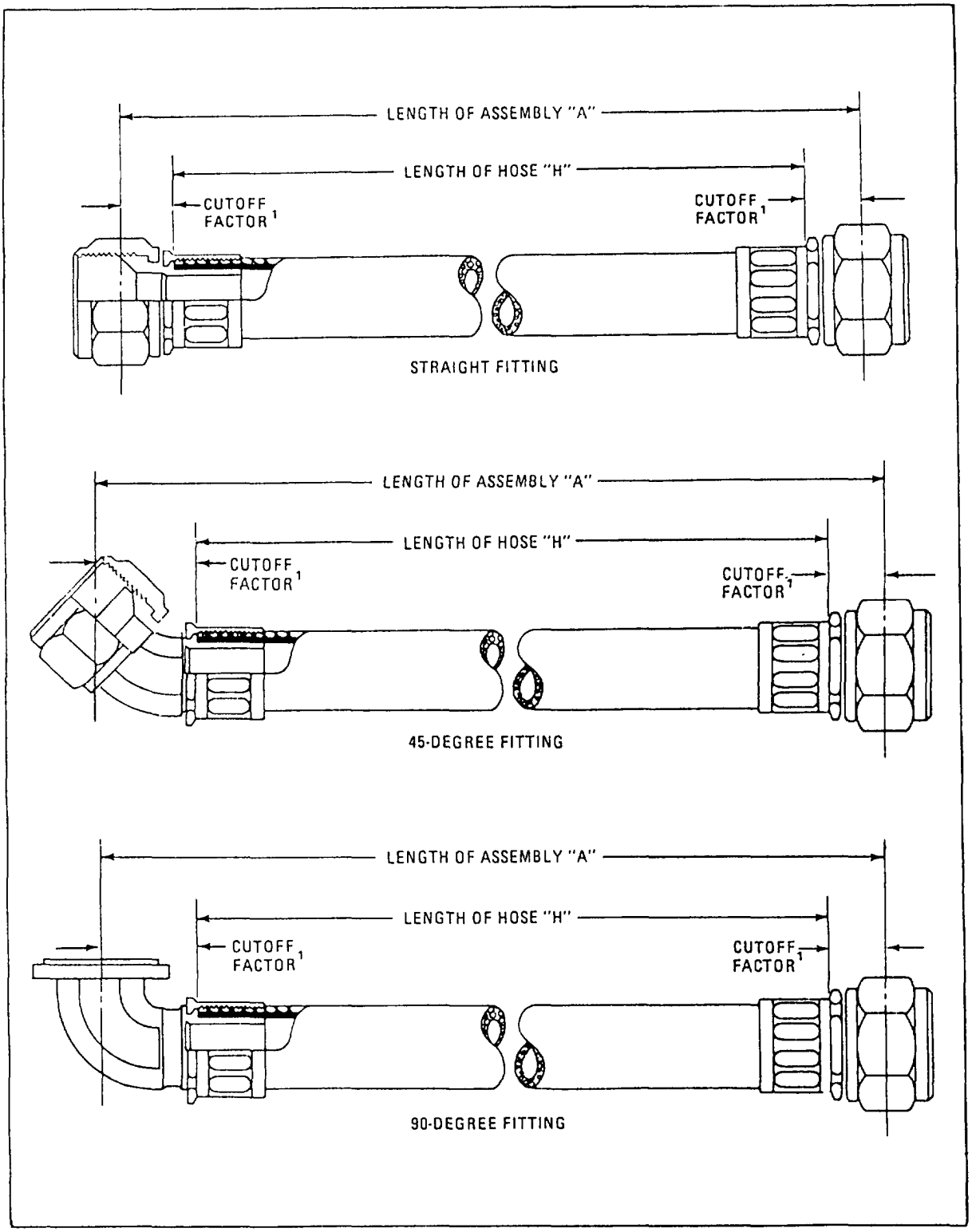


Figure 5-10.—Determining hose assembly length.

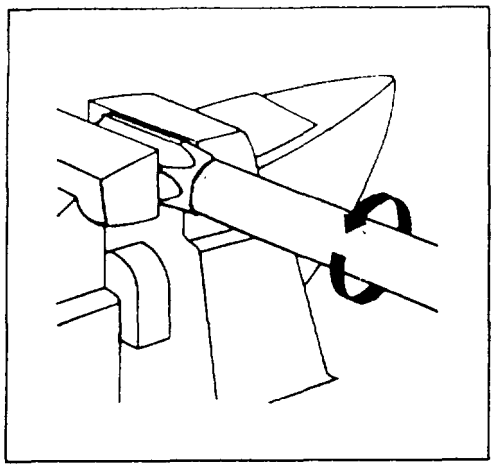


Figure 5-11.—Hose insertion.

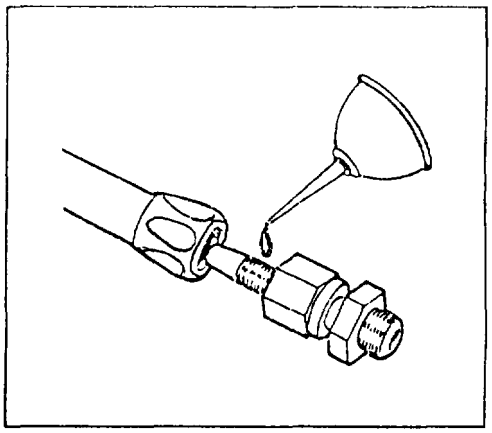


Figure 5-13.—Assembly lubrication.

with tape. Measure the hose to the required length and cutoff the square, using the cutoff machine (fig. 5-7). Blow the hose clean with filtered shop air after cutting. Remove the tape and the clamp socket in a vise (fig. 5-11). Do not overtighten vise on thin-walled lightweight fittings. Screw the hose counterclockwise into the socket using a twisting, pushing motion until the hose bottoms on the socket shoulder. Back the hose out 1/4 turn. Assemble the nipple and nut with a standard adapter of the same size and thread (fig. 5-12). Lubricate the inside bore of the hose and the outside surface of the nipple with hydraulic fluid, MIL-H-5606, MIL-H-83282, or MIL-H-6083 (fig. 5-13). Clamp the socket with the hose into a vise. Insert the nipple assembly into the hose and socket by using a wrench on the hex of the insertion tool. Turn the nipple assembly clockwise until the nut-to-socket gap is between 0.005 and 0.031 inch. The gap allows the nut to turn freely about its axis (fig. 5-14). Remove the insertion tool from the assembly. Repeat the procedure for hose assemblies with straight fittings on both ends.

PREFORMED HOSE ASSEMBLIES.—Medium-pressure Teflon® hose assemblies are sometimes preformed to clear obstructions and to make connections using the shortest possible hose length. Since preforming permits tighter bends that eliminate the need for special elbows, preformed hose assemblies save space and weight. Preformed hose assemblies must be procured from a qualified commercial source (source code P series). When preformed hose assemblies are unavailable and could

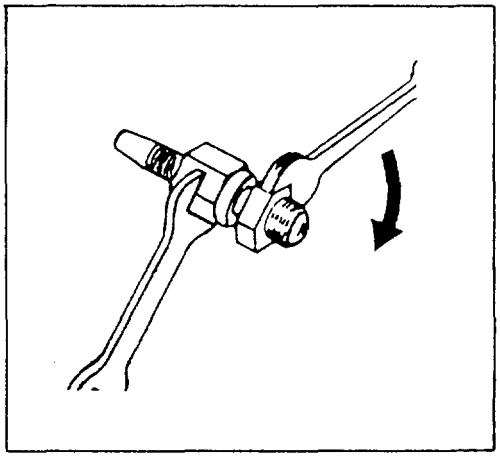


Figure 5-12.—Nipple and nut assembly.

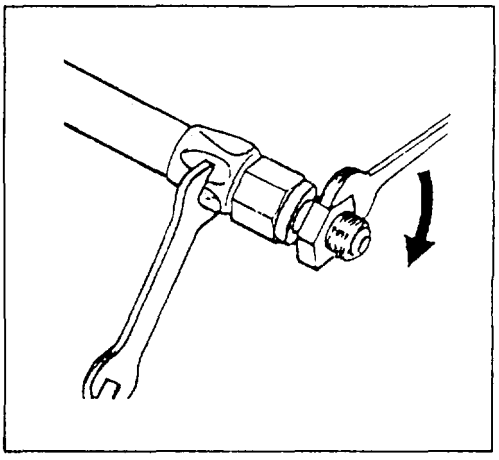


Figure 5-14.—Nipple assembly adjustment.

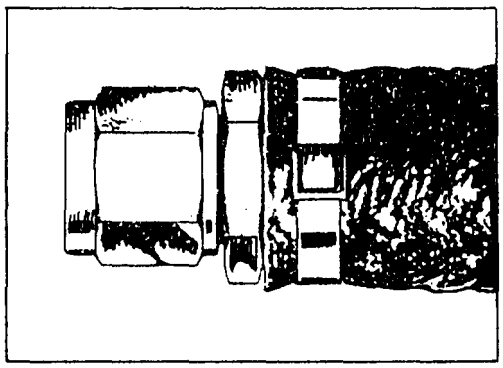


Figure 5-15.—Firesleeve.

cause a work stoppage, fabrication by depot and intermediate maintenance is authorized.

PROTECTIVE FIRESLEEVES.— Some hose assemblies are located in areas where temperatures exceed the capabilities of the hose material. Protective firesleeves should be installed (fig. 5-15) over these hose assemblies. Fire sleeves do not increase the service temperature of hoses, but protect the hose from direct fire long enough to allow the appropriate action to be taken. The sleeve is composed of fiberglass. It is impregnated and overlaid with a flame-resistant silicone rubber.

Cleaning

Fabricated hose assemblies should be cleaned and visually inspected for foreign material before and after proof testing. Cleaning should be done with cleaning fluid or a detergent solution.

In cleaning hose or hose assemblies, the cleaning procedures used depend upon the cleaning material selected for cleaning. See table 5-3. The preferred cleaning method is one that also uses the preferred cleaning material, P-D-680, type II. Note the CAUTION before reading the steps used in the cleaning process.

CAUTION

Oxygen hose assemblies must be cleaned and tested by qualified aviation equipment personnel in accordance with NAVAIR 13-1-6-4 before installation in weapons systems. P-D-680, type II solvent is flammable and its vapors are toxic. Keep P-D-680 solvents away from open flames, and use only in a well-ventilated area. Avoid solvent contact with skin.

Immerse or flush the hose or hose assembly using P-D-680, type II, solvent or equivalent. Brush the exterior of the hose or hose assembly with a nylon or similar synthetic bristle brush that has a corrosion-resistant core. Brush the core and at least the first inch of hose with a brush that has a diameter of at least 1/16 inch larger than the fitting bore. Flush the hose or hose assembly with P-D-680, type II, or equivalent. Drain the cleaning fluid and blow-dry with dry, filtered, oil-free air or nitrogen. Install the protective closures if the hose or hose assembly is not to be cleaned further or proof tested immediately.

Proof Pressure Testing

Hose assemblies must be proof pressure tested after fabrication. Ballistic and oxygen hose assemblies must be cleaned and tested by qualified aviation equipment personnel in accordance with NAVAIR 13-1-6-4 before installation in weapons systems.

Observe all safety rules when you proof pressure test hose assemblies, and proceed as follows to proof pressure test hose assemblies. Clean hose assembly.

Table 5-3.—Alternate Cleaning Fluids for Teflon® Hose or Hose Assemblies

Nomenclature	Specification
Trichloroethane 1.1.1	MIL-T-81533
Trichlorotrifluoroethane	MIL-C-81302 Type II

Select test media from table 5-4. Select proof pressure. See table 5-5, which is a section of the typical hose assembly proof pressure test data sheet. Test one hose assembly at a time. Several hose assemblies that require the same proof pressures may be tested together, if they are connected in series with adapters.

Unless otherwise directed, a manifold hose assembly that contains different sizes or types of hose will be tested at the lowest proof pressure required by any one size or type contained in the manifold. Arrange hose assemblies as close to the horizontal position as possible. Allow trapped air to escape when testing hose assemblies in a liquid test medium. When testing an air or gas medium, test hose assemblies underwater so that trapped air can escape from the hose's braided outer covers. Hose assemblies with a firesleeve do not require the underwater test. Tighten the pressure cap. Apply proof pressure for a minimum of 30 seconds, but no longer than 5 minutes. Check leakage while maintaining proof pressure.

After the completion of the proof pressure test, drain the hose assembly and clean. Install the protective closures. Install the identification tag. Prepare the hose assembly for installation or storage.

AIRCRAFT HOSE BURST TEST STANDS

Learning Objective: *Recognize the two primary aircraft hydraulic hose burst test stands and related operational procedures.*

As previously stated, all flexible hose manufactured in the shop must be hydraulic or pneumatic pressure tested prior to installation in the aircraft. Two types of hose burst test stands, typical of those used for this purposes, are described in the following text.

Table 5-4.—Proof Pressure Test Media

Hose Type	Test Media[1]
Hydraulic	Water, MIL-H-6083 or MIL-H-46170, type II.
Pneumatic or Gaseous	Water, MIL-H-6083, nitrogen (clean, dry and oil-free), air (clean, dry and oil-free) or MIL-H-46170, type II.
Oil	Water or nitrogen (clean, dry and oil-free).
Coolant	Water.
Fuel (nonself-sealing)	Water, MIL-H-6083 or MIL-H-46170, type II.
Fuel (self-sealing)	Water, air (clean, dry and oil-free) or nitrogen (clean, dry and oil-free).
Air	Water or air (clean, dry and oil-free).
Instrument	Water or nitrogen, grade A, type 1 (BB-N-411).

[1] Use Flow Cool or Coolanol for systems using Flow Cool or Coolanol.

Table 5-5.—Hose Assembly Proof Pressure Test Data

Hose Type & MIL-SPEC No.		Test Condition	Hose Size (Dash Number)						
			2	3	4	5	6	8	10
Rubber Low Pressure AN6270		Operating Pressure	300	250	200	——	150	150	150
		Proof Pressure	600	500	400	——	300	250	250
		Burst Pressure	2000	1700	1250	——	1000	750	700
Rubber Medium Pressure MIL-H-8795	HYDRAULIC	Operating Pressure	——	2000	3000	3000	2000	2000	1750
		Proof Pressure	——	4000	6000	5000	4500	4000	3500
		Burst Pressure	——	8000	12000	10000	9000	8000	7000
	FUEL	Operating Pressure	——	1000	1000	1000	1000	1000	1000
		Proof Pressure	——	1500	1500	1500	1500	1500	1500
		Burst Pressure	——	8000	12000	10000	9000	8000	7000
	OIL	Operating Pressure	——	50	50	50	50	50	50
		Proof Pressure	——	600	600	600	600	600	600
		Burst Pressure	——	8000	12000	10000	9000	8000	7000

NOTES:

Typical operating pressures and burst pressure are included for information purposes only.

Operating pressures are minimum (psi min), and proof pressures and burst pressures are maximum (psi max).

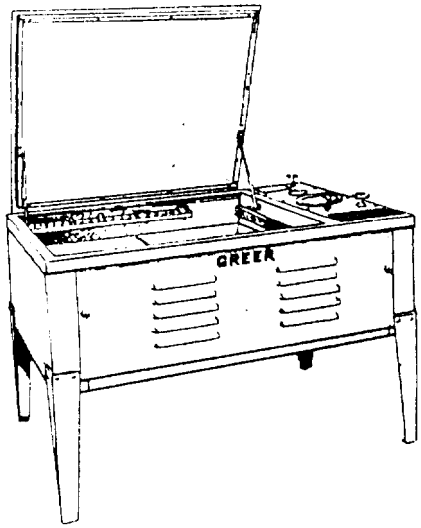


Figure 5-16.—Aircraft hose burst test stand (Greer).

AIRCRAFT HYDRAULIC HOSE BURST TEST STAND (GREER)

The hose test stand shown in figure 5-16 is manufactured by Greer Hydraulics, Incorporated. This test stand is designed especially for proof pressure testing aircraft hose assemblies and is capable of developing static pressures up to 30,000 psi.

The high static pressures required for proof testing are produced by a booster pump powered by shop air having a pressure of 80 to 120 psi. The unit is mounted on four legs, which provide mounting holes for bolting it to the deck. Figure 5-17 shows the instruments and controls, and table 5-6 lists the functions of each. You should be familiar with these instruments and controls before using the test stand. To operate the aircraft hydraulic hose test stand (Greer), follow the procedures described below.

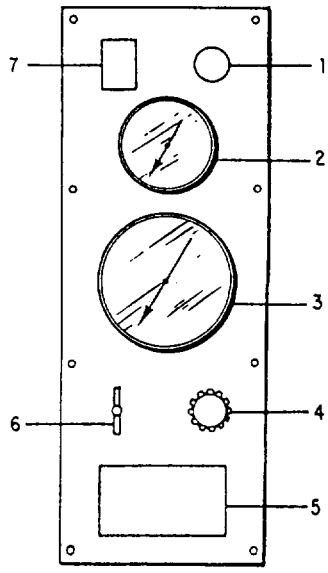
Before you operate the test stand, make the following checks and adjustments: Make sure that the reservoir is filled. Connect the shop air supply line to the stand and open the air shutoff valve. Turn the pressure regulator to the low-pressure position. There are no special starting instructions since the stand starts to operate as soon as air pressure is admitted into the circuit by opening the air shutoff valve. The stand may be warmed up by capping all pressure outlet ports, opening the fluid outlet valve, and allowing the pump to operate for 1 minute.

Installing Hose Lines For Test

With the air pressure regulator set at zero, lift the cover to the open position. Select the proper size adapter (with O-ring) to fit the hose line to be tested, and install it in the pressure manifold outlet port. Connect one end of the test hose line to the manifold adapter. Plug the manifold ports not being used. Connect the bleed valve to the adapter. Connect a second adapter on the other end of the test hose. Close the Plexiglas cover before starting the test.

Test Procedures

Hose lines should be tested in accordance with the applicable military specification; for example, MIL-H-5593 or MIL-H-8794. Each hose specification gives proof test pressures and other pertinent data for that particular type hose. Static pressure is developed by closing the outlet valve and increasing pressure with the pressure regulator. The pressure in the test hose is indicated on the fluid pressure gauge. The red follower pointer will indicate the maximum pressure applied to the hose. This pressure may be increased or decreased by adjusting the pressure regulator.



1. **Shop air shutoff valve**
2. **Regulated air pressure gauge**
3. **Fluid pressure gauge**
4. **Air pressure regulator**
5. **Schematic flow diagram**
6. **Fluid outlet valve**
7. **Nameplate**

Figure 5-17.—Instruments and controls.

Table 5-6.—Function of Controls and Instruments

Index No.	Nomenclature	Functions
1	Air inlet shutoff valve	Connects the shop air to the test stand.
2	Air pressure gauge	This is a 0-160 psi pressure gauge. It registers the regulated air pressure being supplied to the booster pump.
3	Fluid pressure gauge	This is a 0-30,000 psi gauge. It is used to indicate the fluid pressure under which the hose lines are tested. This gauge is provided with a red following pointer and manual reset (for indicating maximum pressure applied to test hose).
4	Pressure regulator	This is a relieving type air pressure regulator. It is used to set the air pressure to the booster pump to give the desired fluid pressure in the pressure manifold. Fluid pressure may be regulated by varying the adjustment on this regulator.
5	Schematic diagram	Mounted on instrument panel.
6	Outlet valve	This is a manual shutoff valve which is used to bleed air from manifold and to relieve fluid pressure upon completion of test.
	Bleed valve (located inside of test chamber).	There are six of these valves. They are used for bleeding air from hoses under test.
	Pressure relief valve (located under panel).	This is a diaphragm type air pressure relief valve. It is adjustable by means of an adjusting screw. This valve limits the air pressure to the desired maximum for safe operating condition. An audible whistling noise is indicated as a warning signal, preventing overpressure and possible damage to the stand components.

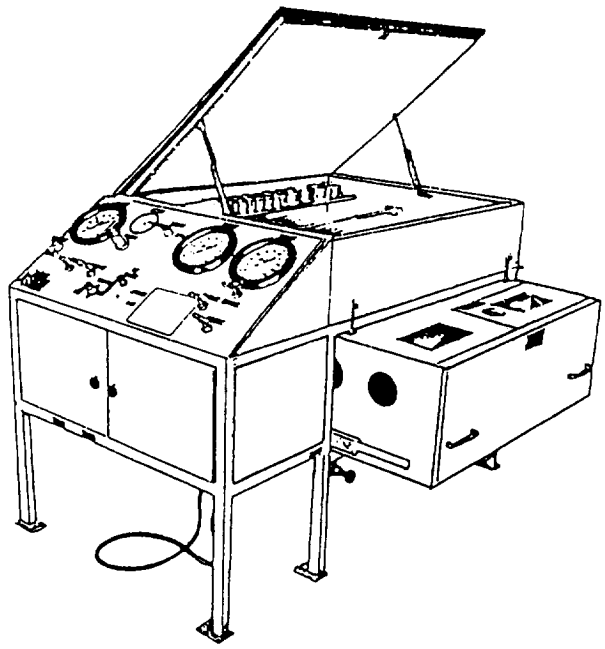
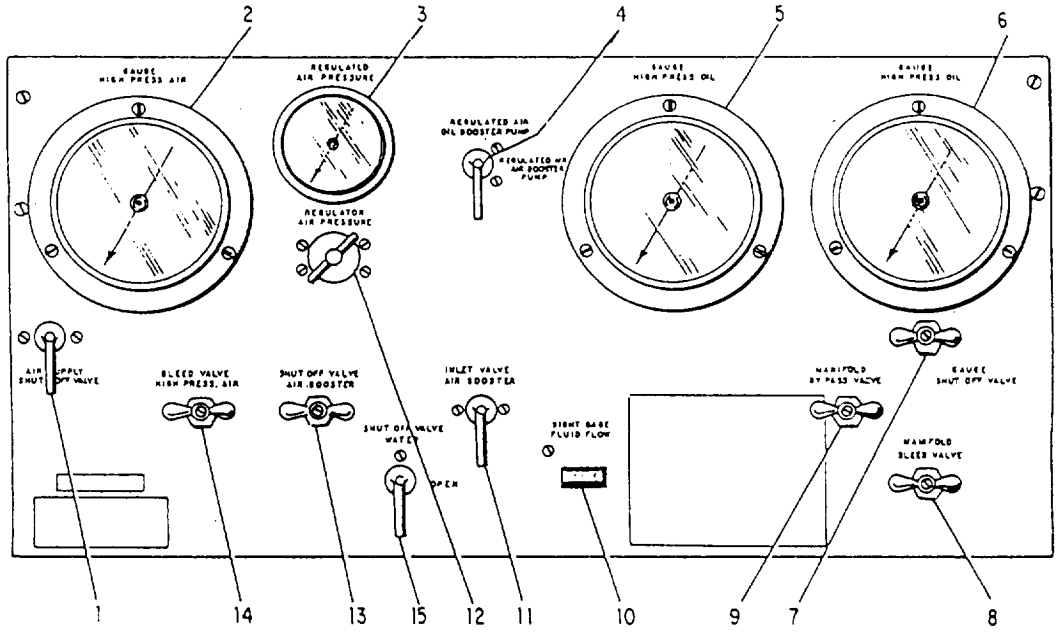


Figure 5-18.—Aircraft hose burst test stand (CGS Scientific).

After the test is complete, the stand is stopped by slowly opening the outlet valve and decreasing the pressure with the pressure regulator. When the fluid pressure gauge reads zero, the Plexiglas cover may be raised, and the test hose is disconnected and removed.

AIRCRAFT HYDRAULIC HOSE BURST TEST STAND (CGS SCIENTIFIC CORP)

The hose burst test stand, shown in figure 5-18, is manufactured by CGS Scientific Corporation. This test stand provides a means for pressure testing of aircraft hose assemblies of various lengths and sizes. Hydraulic pressure up to 15,000 psi and pneumatic pressure up to 1,500 psi are available for the testing of the hoses. The test stand is a completely self-contained unit mounted on legs that permits bolting to the deck. Access doors and removable panels provide easy access to all components for maintenance. Figure 5-19 shows the controls and instruments, and table 5-7 lists the functions of each. You should be familiar with these controls and



1. AIR SUPPLY SHUTOFF VALVE.
2. HIGH-PRESSURE AIR GAUGE (0-2,000 psi).
3. REGULATED AIR PRESSURE GAUGE (0-160 psi).
4. SELECTOR VALVE, REGULATED AIR TO OIL BOOSTER PUMP OR AIR BOOSTYER PUMP.
5. HIGH-PRESSURE OIL GAUGE (0-20,000 psi).
6. HIGH PRESSURE OIL GAUGE (0-2,000 psi).
7. GAUGE SHUTOFF VALVE.
8. MANIFOLD BLEED VALVE.
9. MANIFOLD BYPASS VALVE.
10. SIGHT GAUGE.
11. AIR BOOSTER INLET VALVE.
12. AIR PRESSURE REGULATOR.
13. AIR BOOSTER SHUTOFF VALVE.
14. HIGH-PRESSURE AIR BLEED VALVE.
15. WATER SHUTOFF VALVE

Figure 5-19.—Controls and instruments.

Table 5-7.—Functions of Controls and Instruments

Index No.	Nomenclature	Function
1	Air supply shutoff valve.	Used for turning on and shutting off the shop air supply to the test stand.
2	High-pressure air gauge (0-2,000 psi).	Indicates the air pressure being applied to the hose undergoing pneumatic test. A red follower pointer indicates the maximum pressure applied to the hose. A manual reset knob is provided for resetting the follower pointer to zero.
3	Regulated air pressure gauge (0-160 psi).	Indicates the regulated air pressure being supplied to the oil boost pump or the air boost pump.
4	Selector valve.	Selects regulated air supply for the oil boost pump (hydraulic testing) or the air boost pump (pneumatic testing).
5,6	High-pressure oil gauge (0-2,000 and 0-20,000 psi).	Indicates the hydraulic pressure being applied to the hoses undergoing hydraulic test. A red follower pointer on each gauge indicates the maximum pressure applied to the hoses. A manual reset knob is provided on each gauge for resetting the follower pointer to zero.
7	Gauge shutoff valve.	Provides a means for shutting off pressure to the 0-2,000 psi oil pressure gauge when using test pressures in excess of 2,000 psi.
8	Manifold bleed valve.	Used for bleeding air from the test hoses and manifolds before applying full hydraulic test pressures. Also used to release hydraulic pressure in the test hoses and manifolds after test.
9	Manifold bypass valve.	Bypasses the manifolds when turned on. Used to relieve pressure on the manifolds at the completion of test.
10	Fluid flow sight gauges.	Provides a means for detecting air bubbles in the hydraulic oil passing from the bleed valve to the oil reservoir.
11	Air booster inlet valve.	Used to turn on and shut off the unregulated air supply to the air boost pump.
12	Air pressure regulator.	Used for setting the input air pressure to the oil boost pump during hydraulic testing to give the desired hydraulic test pressure. Also used for setting the input air pressure to the air boost pump during pneumatic testing to give the desired pneumatic test pressure.
13	Air booster shutoff valve.	May be turned off after pressure is built up in the test hose; it holds the test pressure and permits the air booster to be shut down.
14	High-pressure air bleed valve.	Provides a means for releasing the air pressure in the test hose after test.
15	Water shutoff valve.	Used for turning on the water to fill the pneumatic test chamber.

instruments before using the test stand. To operate the hose burst test stand (CGS Scientific), follow the procedures listed below.

Before you perform the following preliminary adjustments, ensure that the air and electrical systems are energized. Check the reservoir oil level. If the reservoir is not full, add hydraulic oil. Make sure that the manifold bypass valve is closed. Open the manifold bleed valve. Make sure that the air booster inlet valve is closed. Make sure that the high-pressure air bleed valve is closed. Set the air pressure regulator for minimum pressure (fully counterclockwise). Turn on the gauge shutoff valve. Set red follower needles on the gauges to zero.

Installing Hose Lines For Test

For the hydraulic testing of hoses, take the following actions. Open the Plexiglas door on the hydraulic test chamber. Remove the plugs from the manifold ports. Select the proper size adapters for the hose lines being tested, and install them in the manifold ports. Connect the hose lines to be tested between the two manifolds. Close the hinged door at the top of the test chamber.

> **NOTE:** The distance between the manifolds is adjustable for various hose lengths. Loosen the thumbscrews that secure the rear manifold and slide it backward or forward on the tracks to obtain the desired distance.

For the pneumatic testing of hoses, take the following actions. Unlock the two side bolts that secure the pneumatic chamber in the retracted position. Pull out the chamber to the extended position and secure it with the two slide bolts. Unlatch and open the two doors at the top of the pneumatic chamber. Open the hinged screens inside the chamber. Select a suitable adapter and connect the hose to be tested to the connection in the chamber. Use a suitable plug to seal the opposite end of the test hose. Close the hinged screens. Close and lock the two doors at the top of the chamber.

Test Procedures

Hose lines should be tested in accordance with the applicable military specification. Each hose specification gives proof test pressures and other pertinent data for that particular type of hose. Perform hydraulic testing as follows: Make all the preliminary adjustments and install the test hoses as described previously. Turn the selector valve to the oil boost pump position. Turn on the air supply shutoff valve. Slowly open the air pressure regulator until air-free oil passes through the fluid flow sight gauge; then close the manifold bleed valve. Increase the pressure on the test hoses to the specified value by adjusting the air pressure regulator until the desired pressure is indicated on the high-pressure oil gauges.

CAUTION

> **If pressure will exceed 2,000 psi, turn off the gauge shutoff valve. This shuts off the pressure to the 0-2,000 psi high-pressure oil gauge. Continue to read the 0-20,000 psi gauge. The test hoses may be observed through the Plexiglas window in the test chamber door while under test pressure. The pressure may be increased during test by adjustment of the air pressure regulator.**

To perform pneumatic testing, proceed as follows. Make all the preliminary adjustments and install the test hoses as described previously. Turn on the air booster inlet valve. Make sure that the air booster shutoff valve is turned on. Turn the selector valve to the air boost pump position. Turn on the air supply shutoff valve. Increase the pressure on the test hose by adjusting the air pressure regulator until the desired pressure is indicated on the high-pressure air gauge.

CAUTION

> **Keep the test hose at test pressure for 2 minutes before turning on the water shutoff valve. A ruptured test hose, with water in the pneumatic chamber, could cause injury to personnel.**

Turn on the water shutoff valve and fill to the level inside the test chamber. Observe the test hose for air leaks through the shatterproof glass windows at the top of the test chamber. Air bubbles rising in the water indicate a leaking hose or fitting. When you complete the hydraulic test, stop the operation of the test stand. Adjust the air pressure regulator for a zero reading on the regulated air pressure gauge. Shut the air supply shutoff valve. Open the manifold bypass valve. When the high-pressure oil gauge indicates a

zero pressure, open the test chamber door and disconnect and remove the test hoses.

After you complete the pneumatic test, stop the operation of the test stand. Adjust the air pressure regulator for a zero reading on the regulated air pressure gauge. Shut off the air supply shutoff valve. Open the high-pressure air bleed valve. When the high-pressure air gauge indicates a zero reading, drain the water by means of the drain valve at the bottom of the chamber. Open the test chamber doors and disconnect the test hose.

HOSE AND HOSE ASSEMBLY MAINTENANCE

Learning Objective: *Recognize the maintenance procedures and practices associated with hose and hose assembly maintenance.*

Maintenance of hose and hose assemblies at the organizational level is limited to contamination control, preventive maintenance, removal, installation, or replacement. Proper maintenance practices can minimize the problems that might occur with regard to hose and hose assemblies.

MAINTENANCE PRACTICES

Do not use hose or hose assemblies as foot or hand holds. Do not lay hose or hose assemblies where they may be stepped on or run over by vehicles. Do not lay objects on hose or hose assemblies. Turn the swivel nut when loosening or tightening fittings. Hold the socket only to prevent the hose assembly from turning. Perform all necessary turnoff or shutdown procedures as outlined in the applicable maintenance instruction manuals (MIMs) or technical directives before removing any hose or hose assembly. Cover open ends of hose, hose assemblies, and fittings with protective closures. Make sure hose, hose assemblies, and connection points are cleaned before installing.

PREVENTIVE MAINTENANCE

Preventive maintenance consists of periodic inspection and correction of hose and hose assembly faults. In this process, you must check for leaks, wear, and deterioration. Special attention must be paid to hose or hose assemblies and clamps.

Checking For Leaks

Hose or hose assemblies should be replaced when leaks are found to be caused by damage to any part of a hose or hose assembly; poor seating or damaged threads of the socket or nipple assembly, which causes the fitting to leak; or excessive torque. If a leak appears in the swivel nut area, check that the swivel nut is properly torqued. If necessary, disconnect fitting and check for contamination or damage. If the leak persists after cleaning, and the swivel nut is properly torqued, replace the hose assembly.

Checking For Wear and Deterioration

Check hose and hose assemblies for signs of wear and deterioration. Replace any hose or hose assembly when a chafe guard appears worn or shows signs of cracking; when a firesleeve is worn through, torn, cut, or oil soaked; when hose or hose assembly has weather protective coatings or sleevings that are worn, cracked, or torn, thus exposing the hose or hose assemblies to corrosion.

Checking Hose or Hose Assembly Installations

Check hose or hose assembly installations carefully. Proper routing and clamping in accordance with applicable MIM is mandatory. If retaining wires on swivel nuts are backed out, replace the hose assembly. Look for kinks or twists. Observe lay line, if possible. A kinked hose or hose assembly must be replaced. A twisted hose or hose assembly may be relieved by loosening clamps and swivel nuts, and then straightening the hose by hand. Retorque the swivel nuts and tighten the clamps. A preformed hose, or hose assembly, may have a smaller bend radius. Do not attempt to straighten preformed hose or hose assemblies. Excessive bends or signs of chafing may be due to loose, oversize, or worn clamps. Replace oversized or worn clamps, and tighten the clamp without squeezing the hose.

Checking Clamps

You should check the clamps to make sure they are the correct type and size, that the position of the hose is correct within the clamp, and that the cushion material is positioned correctly. Reposition hose and clamps as needed. Cushion material should NOT lodge between end tabs of a closed clamp. Do NOT use clamps with fuel-resistant cushioning

unnecessarily, as this type of cushioning material deteriorates rapidly when exposed to air.

REMOVING HOSE OR HOSE ASSEMBLIES

Hose or hose assembly removal procedures must include contamination control procedures as well as actual removal procedures to prevent contamination to the opened system.

Contamination Control Procedures

Perform contamination control procedures before removing any hose or hose assemblies. You should use approved solvents and clean, lint-free cloths to clean the affected area and wipe down fittings to remove excessive contaminants. Use a suitable container to catch spilled fluid. Have replacement hose, hose assemblies, or protective closures on hand for installation when you disconnect hose or hose assemblies. If hose replacement is not practical, cap or plug hose or hose assembly ends immediately after disconnecting.

Removal Procedures

Once contamination control has been accomplished, you can begin removal of hose and hose assemblies. Remove all supporting clamps from hose or hose assembly. Remove lockwire (if present) from swivel nuts. Turn swivel nuts only to disconnect hose assembly. Loosen nuts carefully to avoid damage. Disconnect the hose assembly by using two open-end wrenches. One is to grip and prevent turning of the fitting to which the hose assembly is connected, and the other is to loosen the swivel nut.

Hose and hose assemblies (particularly Teflon®) have a tendency to become set to shape in service. Some Teflon® hose assemblies are deliberately preformed during the fabrication process. Do not attempt to straighten a preformed hose. Protect the preformed areas from distortion by a restrainer. The restrainer may be of wire, metal, plastic forms, or any other suitable device to retain the preformed configuration. Install the protective closures to seal open parts of hydraulic lines and ends of removed hose or hose assemblies.

INSTALLING HOSE OR HOSE ASSEMBLIES

When you install hose or hose assemblies, it is important that you follow certain practices or procedures to prevent premature failure of hose or hose assembly or possible injury. Before you begin actual installation procedures, there are guidelines you should remember about installing hose or hose assemblies. The replacement hose or hose assembly must be a duplicate of the one removed in length, outside diameter, material, type, contour, and associated markings.

Only fluid conforming to MIL-H-5606, MIL-H-83282, or MIL-H-81019 is to be used on hydraulic or pneumatic hose installations. Do not use oil of any type on self-sealing hose as an aid to installation. Compatible oil, approved for the purpose, may be used on all other types of fuel, oil, and coolant hose installations.

When you install or handle hose or hose assemblies, you can sustain injuries to your hands or damage to the hose if it is kinked. You should take care to prevent situations where injuries or kinking can occur. A hose that is bent to a smaller radius than specified might cause kinking. See table 5-8.

A preformed hose assembly, or one that has become set-to-shape of its operating position, is straightened or handled without a protective restraint. A hose or hose assembly that is twisted during handling, removal, or installation can easily cause kinking.

Preinstallation Procedures

Check hose or hose assembly before installing it to make sure that identification bands and protective closures are present as required after proof pressure testing. Inspect hose for proper type and size, and for aging (signs of deterioration such as cracks, discoloration, hardening, weather checking, or fungus). Check the braid for two or more broken wires per plait, or more than six broken wires per linear foot. Inspect for broken wires where kinking is suspected. Evidence of internal restriction of tube due to collapse, kinking, wire-braid puncture, or other damage can be found by using one of the following methods of inspection: For straight hose assembly, insert a light at one end and visually inspect from the opposite end. For elbow fitting on both ends (practical for larger sizes only), insert flexible

Table 5-8.—Hose Minimum Bend Data

RUBBER HOSE								TEFLON®HOSE			
Low PRESSURE MIL-H-5593		MED PRESSURE MIL-H-8794		MED PRESSURE LTWT MIL-H-83797		HIGH PRESSURE MIL-H-8788		MED PRESSURE MIL-H-27267		HIGH PRESSURE MIL-H-83298	
HOSE DASH No.	MINIMUM BEND RADIUS (INCHES)	HOSE DASH NO.	MINIMUM BEND RADIUS (INCHES)	HOSE DASH NO.	MINIMUM BEND RADIUS (INCHES)	HOSE DASH NO.	MINIMUM BEND RADIUS (INCHES)	HOSE DASH NO.	MINIMUM BEND RADIUS (INCHES)	HOSE DASH NO.	MINIMUM BEND RADIUS (INCHES)
2	2.00	2	—	2	—	2	—	2	—	2	—
3	2.00	3	3.00	3	1.75	3	—	3	2.00	3	—
4	4.00	4	3.00	4	2.00	4	3.00	4	2.00	4	3.00
5	—	5	3.38	5	2.25	5	3.38	5	2.00	5	—
6	4.00	6	4.00	6	2.50	6	5.00	6	4.00	6	5.00
8	6.00	8	4.62	8	3.50	8	5.75	8	4.62	8	5.75
10	6.00	10	5.50	10	4.00	10	6.50	10	5.50	10	6.50
		12	6.50	12	4.50	12	7.75	12	6.50	12	7.75
		16	7.38	16	5.50	16	9.62	16	9.00	16	9.62
		20	9.00	20	8.00					20	12.00
		24	11.00	24	9.00	*16Z	7.38	*16Z	7.38		
		32	13.25	32	12.50	*20Z	11.00	*20Z	11.00		
		40	24.00			*24Z	14.00	*24Z	14.00		
		48	33.00								

Z—Designated two stainless steel wire braids.

NOTE: Bend Radius for MIL-H-600 and MIL-H-7938 hose shall not be less than 12 times the inside diameter of

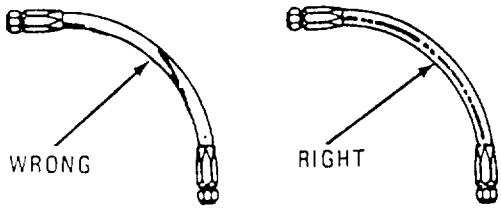


Figure 5-20.—Hose twist.

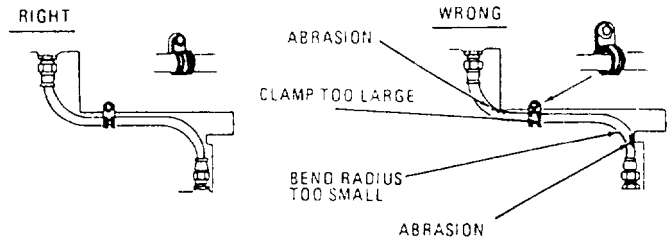


Figure 5-22.—Hose clamp mounting.

inspection light into one end and visually inspect from the opposite end using a small, angled, dental-type mirror. Inspect for any separation of covers or braids from inner tube, or from adjacent covers or braids. Look for flaring or fraying of braid. Look for blisters, bubbles, or bulging. Inspect for corrosion. A hose that has carbon steel wire braid is subject to corrosion, which may be detected as brownish rust coloration penetrating the outer braid.

Inspect end fittings for proper type and size, corrosion and cleanliness, nicks, scratches, or other damage to the finish that affects corrosion resistance. Look for damage to threaded areas, damage to cone-seat sealing surfaces damage to flange fittings, warping of flange, and for nicks or scratches on the sealing surface or gasket.

Installation Procedures

Remove the protective closures from hydraulic lines, hose, or hose assemblies. When possible, install hose or hose assemblies so that identification markings are visible. Install hose or hose assemblies without twisting, chafing, or overbending (fig. 5-20).

Observe bend radius in table 5-8. Greater bend-radius is preferred where possible. Install hose or hose assemblies with a slight bow or slack to compensate for contraction pressure on the line (fig. 5-21).

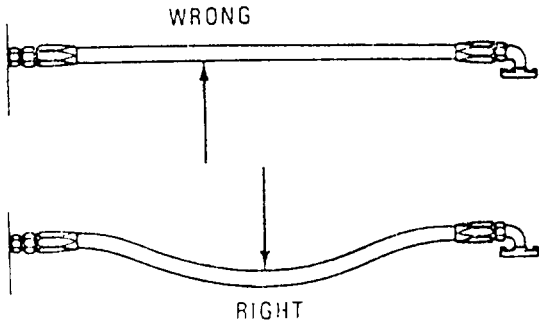


Figure 5-21.—Hose slack.

When connecting hose or hose assemblies to an engine or an engine-mounted accessory, provide 1 1/2 inches of slack or a suitable bend between the last point of support and the engine or accessory attachment. Fingertighten swivel connector nuts to avoid stripping threaded areas of fittings. Before applying final torque to end fittings, make sure hose

Table 5-9.—Swivel Nut Installation Torque (Inch-Pound) for Flared and Flareless Fittings

HOSE SIZE	STEEL		ALUMINUM	
	MIN	MAX	MIN	MAX
2	75	85	20	30
3	95	105	25	35
4	135	145	50	65
5	170	190	70	90
6	215	245	110	130
8	430	470	230	260
10	620	680	330	360
12	855	945	460	500
16	1140	1260	640	700
20	1520	1680	800	900
24	1900	2100	800	900
32	2660	2940	1800	2000

NOTE: Torque values based on lubrication with fluid MIL-H-5606 or MIL-H-83282 prior to installation.

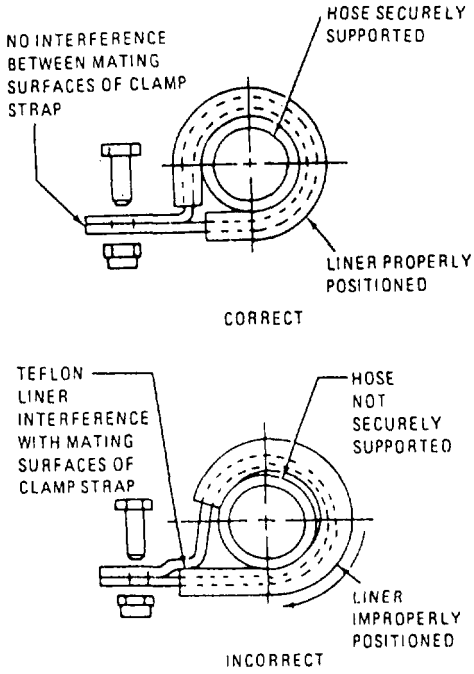


Figure 5-23.—Clamp installation.

assemblies are properly aligned and free of twists and kinks. Complete tightening by using torque values specified in applicable MIM. Table 5-9 is a guide for installation torque of flared and flareless fittings.

Hold fitting stationary with one wrench, and use torque wrench to tightens wivel nut. When applying final torque, hold hose manually to prevent rotation and scoring of the fitting's sealing surface. Lockwire the swivel nut (if applicable). Support flexible hose or hose assemblies by routing and clamping hose or hose assembly securely to avoid abrasion and kinking where flexing occurs (fig. 5-22).

Overtightening clamps will squeeze or deform hose. Cushion-type clamps should be used to prevent hose chafing. See figure 5-23.

Make sure support clamps do not restrict hose travel or subject hose or hose assembly to tension, torsion, compression, or sheer-stress during flexing cycles. Where flexing is required in an installation, bend the hose in the same plane of movement to avoid twisting. Ensure that the minimum bend radius is greater by a factor of "N" than the minimum bend radius for a nonflexing hose for hose assemblies required to flex at a bend (fig. 5-24).

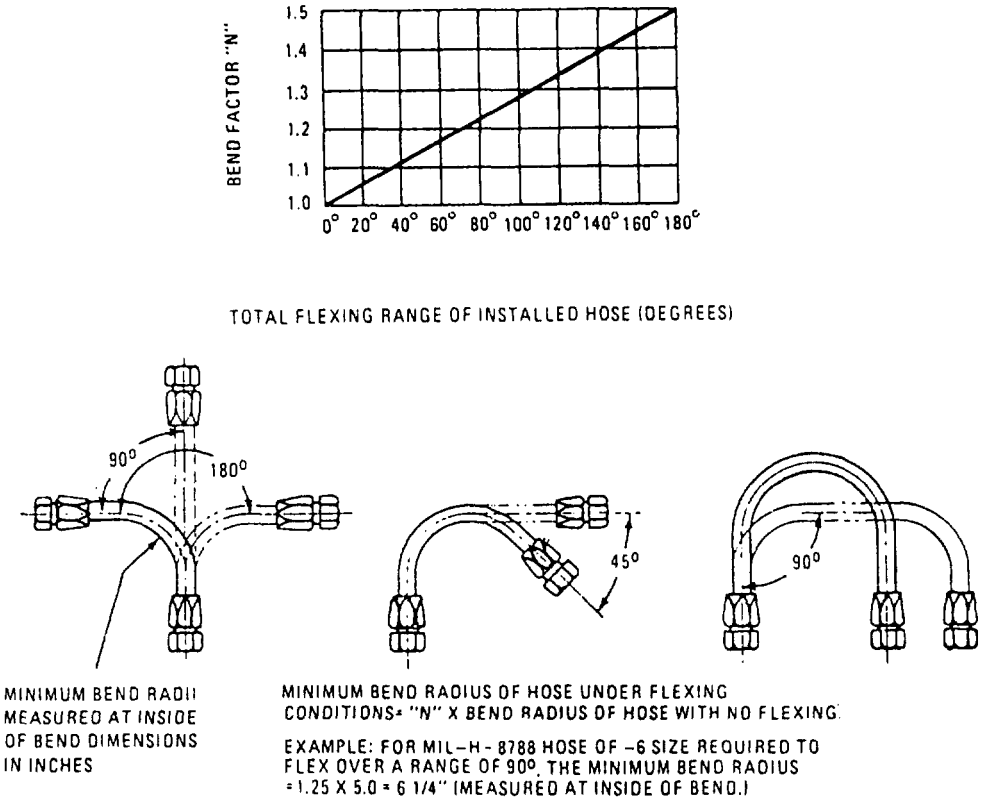


Figure 5-24.—"N" factor for flexing bends.

AGE CONTROL AND SERVICE LIFE

Hose or hose assemblies fabricated from age-sensitive materials are subject to age control. The following definitions are provided to clarify age control, acceptance life, shelf life, and service life:

• Age control—The efforts made during manufacture, purchase, and the storage of age-sensitive items and parts made from natural or synthetic rubber materials to assure conformance to the applicable material and performance specifications. Age control is further defined in terms of acceptance life and shelf life.

• Acceptance life—The period of time from cure date to the procuring activity's (organizational-, intermediate-, or depot-level activity) date of acceptance.

• Shelf life—The period of time from the date of acceptance or delivery by the organizational-, intermediate-, or depot-level activity to the date of use.

• Service life—The period of time from the date of installation to the date of removal. Installation date of the hose or hose assemblies must be identified by a tag. See figure 5-5.

Acceptance Life and Shelf Life for Synthetic Rubber Hose and Hose Assemblies

The acceptance life (MIL-STD-1523) and shelf life (DOD 4140.27M) for synthetic rubber hose and hose assemblies are established as follows:

• Synthetic rubber hose, bulk or assembly, must not exceed 8 years (32 quarters) from the cure date, which must be stenciled on the rubber covering of the bulk hose or provided on an identification band on the metal braid hose or on the hose assemblies.

• Synthetic rubber hose and hose assemblies must not exceed 5 years (20 quarters) from the date of delivery to the organizational-, intermediate-, or depot-level activity. The repair activity maintains a record of delivery dates for bulk hose and hose assemblies to monitor shelf life expiration dates.

NOTE: Teflon® (PTFE) rubber hose and hose assemblies do not have shelf life limitations.

Service Life for Synthetic Rubber Hose Assemblies

Service life is 7 years (28 quarters) for synthetic rubber hoses in critical applications; that is, medium- and high-pressure synthetic rubber hoses exposed to heat, weather, or fuel.

NOTE: Service life for Teflon® (PTFE) hose assemblies is determined by CFA and may be on-conditional replacement or hard-time replacement.

Rejection Standards

Rejection and replacement of hose or hose assemblies after inspections are based on the standards normally specified in the applicable maintenance instruction manual, maintenance requirement cards, and depot-level specifications. Where rejection standards are not specifically outlined or if doubt exists as to the acceptability of a hose or hose assembly, replace the hose or hose assembly.

NOTE: Teflon® (PTFE) hose assemblies are replaced only on a conditional basis.

STORAGE

Hose and hose assemblies fabricated from age-sensitive materials are subject to deterioration by oxygen, ozone, sunlight, heat, moisture, or other environmental factors. These types of hoses and hose assemblies should be stored in a dark, cool, dry place protected from circulating air, sunlight, fuel, oil, water, dust, and ozone (ozone may be generated in an atmosphere where electricity is discharged through oxygen or ambient air). Store hose or hose assemblies by sealing both ends of bulk hose. Cap or plug each hose or hose assembly. Store hose or hose assemblies on racks that support and protect them. Store hose or hose assemblies so that the oldest items are issued first.

CAUTION

Do not store hose or hose assemblies in piles. Improper storage will cause accelerated deterioration due to both heat and moisture factors.

RECOMMENDED READING LIST

NOTE: Although the following references were current when this TRAMAN was published, their continued currency cannot be assured, Therefore, you need to be sure that you are studying the latest revision.

Aviation Hose and Tube Manual, NAVAIR 01-1A-20, Naval Air Systems Command, Washington, D.C., June 1989.

Aviation Hydraulics Manual, NAVAIR 01-1A-17, Commander, Naval Air Systems Command, Washington, D.C., 1 February 1992.

Fluid Power, NAVEDTRA 12964, Naval Education and Training Program Management Support Activity, PensacoIa, Florida, July 1990.